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**Taming the Information Firehose -
Command and Control for 2000 and Beyond**

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.
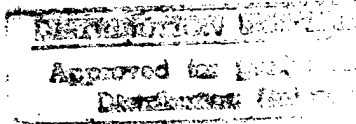
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15.Abstract: Information requirements have grown drastically in conjunction with the increased complexity of today's battlefield in terms of time, space, and force diversity. We are now on the verge of significantly lifting the "fog of war", giving commanders and staffs at all echelons a clearer and greatly expanded view of the battlefield. As real-time high resolution imagery and live video, weather overlays, enemy templates, situation assessments, spot reports, friendly location and status, and a host of other information is pushed out to the field in ever increasing quantity and speed, our technological successes threaten to overwhelm commanders with "too much of a good thing." It is at the operational level of warfare that the commander is most likely to be caught in the blast of this potential information firehose. Responsible for implementing strategic guidance from above and planning and orchestrating campaigns or operations ranging from joint to combined that must successfully be translated into victorious tactical actions at echelons below, the operational commander represents the critical juncture for information traffic. The purpose of this paper is to discuss the information management issues that must be addressed to support the C2 process for maximizing decision quality, communication, and execution, and minimizing the commander's decision cycle. These issues include man-machine interfaces, workflow and retrieval, and organizational support structures.

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Abstract of

**Taming the Information Firehose -
Command and Control for 2000 and Beyond**

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complexity of today's battlefield in terms of time, space, and force diversity. We are now on the

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List of Illustrations

Information is the currency of victory on the battlefield.

GEN Gordon Sullivan, CSA (1993)[1]

Information requirements have grown drastically in conjunction with the increased complexity of today's battlefield in terms of time, space, and force diversity.[2] We are now on the verge of significantly lifting the "fog of war", giving commanders and staffs at all echelons a clearer and greatly expanded view of the battlefield. As real-time high resolution imagery, live video, weather overlays, enemy templates, situation assessments, spot reports, friendly location and status, and a host of other information is pushed out to the field in ever increasing quantity and speed, our technological successes threaten to overwhelm commanders with "too much of a good thing." It is at the operational level of warfare that the commander is most likely to be caught in the blast of this potential information firehose. Responsible for implementing strategic guidance from above and planning and orchestrating campaigns or operations ranging from joint to combined that must successfully be translated into victorious tactical actions at echelons below, the operational commander represents the critical juncture for information traffic. To illustrate the potential magnitude of the problem, consider that at the peak of Desert Storm operations over 700,000 telephone calls and 152,000 messages were passed *daily* over a hybrid theater communications system.[3] The issue and challenge is well summarized in a 1989 RAND study:

> "The problem is viewed as a function not so much of unavailable information as of getting the right information in the right form to the right place at the right time, to be used in the right way. Each of these elements -- content, format, location, timing, and use -- is *necessary* to good command and control."[4]

1

Conversely, command and control (C2) both as a process and a system plays a central role in managing information collection and dissemination. Serving as the glue that binds other operational level functions such as fires, logistics, movement and maneuver, intelligence, and protection, the C2 process "is the means by which the commander synchronizes joint force activities in time, space, and purpose in order to achieve Service and functional component unity of effort with respect to strategic objectives."[5] But as the operational commander's most critical supporting process and tool, today's C2 suffers from information overload.

So how do we regulate the information firehose? The purpose of this paper is to discuss some of the information management issues that must be addressed to support the C2 process for maximizing decision quality, communication, and execution, and minimizing the commander's decision cycle. These issues include:

◊   man-machine interfaces -- information presentation,

◊   workflow & retrieval-- the process for information collection and distribution, and

◊   support structures -- organizations that manage information

Man-Machine Interfaces

"A forest ranger spots the smallest fire by watching for telltale signs from a lookout high above the treetops, not by running from tree to tree in search of flames."[6]

The operational commander receives information in a wide variety of forms. Compared to the ability process text, the human brain can process visual information at least 100 times faster.[7] Although no picture or message text can currently convey the critical information embedded in tone of voice during verbal communication, visual representation of information presents a powerful tool in reducing information overload. It does this through abstraction --

a technique for managing complexity by rolling up details and representing this aggregation in easy to grasp formats.[8] A simple example is the use of color. Viewing color coded charts, a commander can quickly absorb force status and focus on problem areas.

One of the lightening rods focusing multi-service development efforts in joint operational C2 is the concept of a "common picture of the battlefield" available to forces at all echelons. Battlefield visualization, a closely related and supporting concept, is defined by TRADOC Pamphlet 525-70 as:

> "The process whereby the commander develops a clear understanding of the current state with relation to the enemy and environment, envisions a desired end state which represents mission accomplishment, and then subsequently visualizes the sequence of activity that moves the commander's force from its current state to the end state."[9]

While human factors will always play a critical role in visualizing the battlefield, the job of delivering a comprehensive yet relevant battlefield picture to the operational commander falls increasingly to computers; more specifically, to the computer interface -- the medium for information determination (what you want to see) and presentation (how you want to see it). Alan Cooper succinctly defined the ideal objective when he stated that "Good user interfaces are invisible."[10] This is an extremely important goal because distractions caused by poor interfaces that make information hard to select or digest translate directly into expanded decision cycles and incomplete or even inaccurate understanding. Identifying a minimal set of required information would simplify interface design considerations significantly. Unfortunately, despite numerous studies to extract the essence of the commander's critical information requirements (CCIR), the particular information that is critical at any given moment remains predominantly situation dependent.[11] Under these circumstances, battlefield

visualization needs the flexibility to observe the entire battlespace spectrum, zoom in on a specific area, or even drill down levels of detail to scrutinize conditions at a decisive point.

A critical process used by the operational commander when planning an operation is the Commander's Estimate of the Situation (CES).[12] Analysis of the mission handed down by the immediate superior leads to an initial visualization of the battlefield, which in turn exposes critical gaps in knowledge and understanding. This serves as the preliminary identification of CCIR and establishes a filter to shield the operational commander from information overload.[13] Furthermore, mission analysis identifies the critical tasks and objectives at the operational level and results in a restated mission, planning guidance, and an initial operational commander's intent. Together with the CCIR and superior's intent, this synthesis of command direction serves to direct information collection, focus the staff in their preparation of estimates, and guide the planning of subordinate commanders two echelons down. Within this framework, staffs then identify and analyze courses of action (COA) and brief their findings to the operational commander who will ultimately decide on a COA, develop a concept of operations, and supervise the publication of the operations order (OPORD). Given the CES process described above, how can interface related considerations help the operational commander a) formulate his image, b) translate that image into a statement of intent and communicate that intent to subordinates, and c) monitor understanding and execution of intent and mission?

Visualizing the Battlefield - The operational commander must employ abstraction and prioritization to develop his battlefield image. He needs to be able to focus on one information source and through an iterative process of manipulation, filtration, and

adjustment, formulate a picture of the existing situation relevant to his mission and superior's intent. Advances in sensors, data transmission speeds, storage, global connectivity, and large flat panel displays have made the electronic situation map an increasingly important tool for accomplishing this. As seen in Figure 1 below, battlespace information across the breadth, depth, and height of the theater of operations is becoming increasingly available at granularities unimaginable only a few years ago. View tailoring, both vertically by echelon and horizontally across functions and service components, is required to facilitate not

Figure 1 - Battlefield Visualization
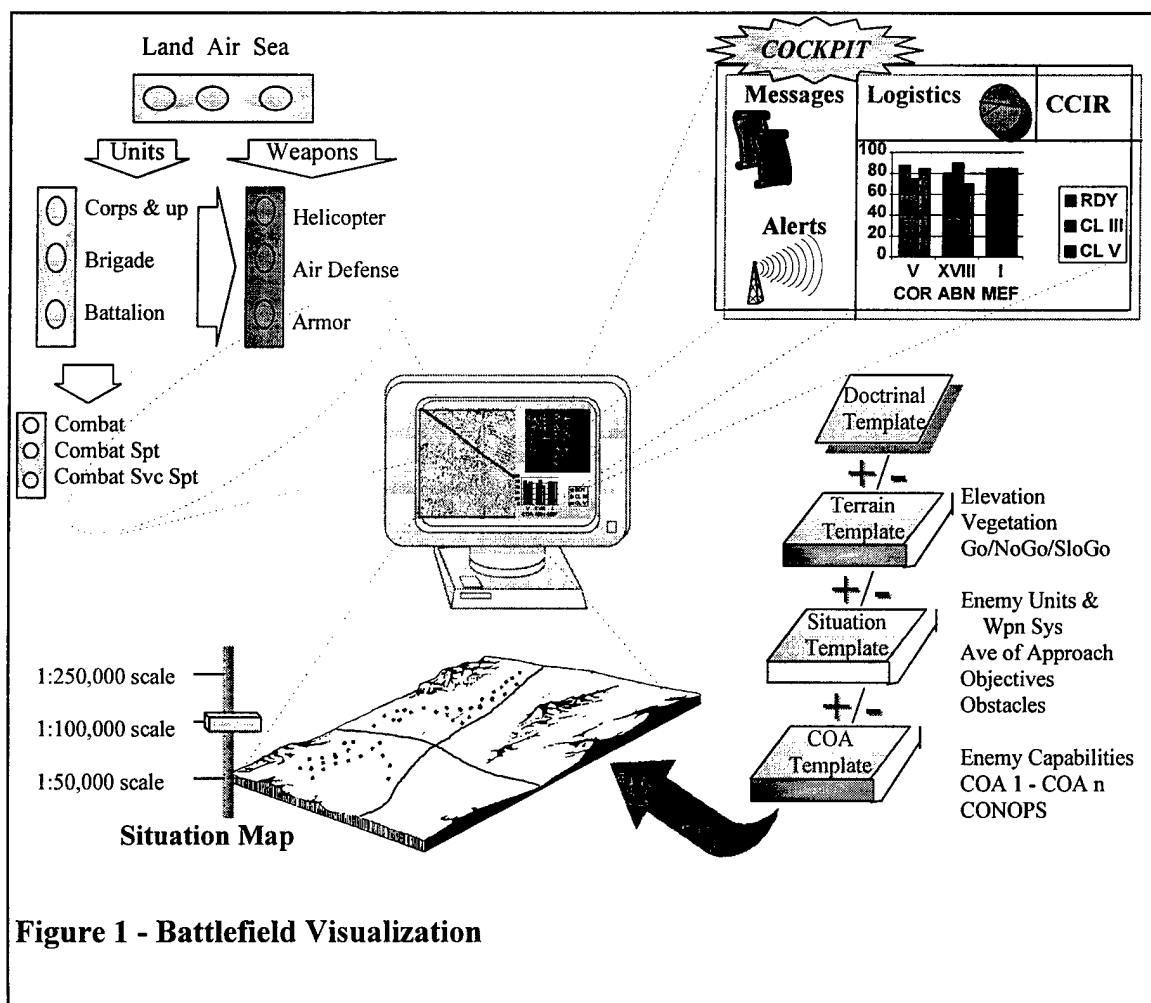
only building the picture but to accommodate differences in command style, technique, and perspective. The ability to save "views" is a necessary and important tool for managing

complexity by allowing the commander to focus on different aspects of his mission within the overall battlespace. For example, one view may concentrate specifically on high level enemy positions, avenues of approach, fortifications, and obstacles across the entire area of operations. Another view might include similar information at a much lower level of detail with more elaborate terrain visualization, but limited to a very small physical area surrounding an objective or decisive point. The need to visualize the battlefield through easy to use view tailoring highlights the importance of the man machine interface as a tool for managing information overload. Figure 1 is not intended to suggest the perfect interface (more elaborate schemes either exist or are under development), but merely demonstrates a sample range of considerations. Other interface capabilities that could be incorporated include:

⇒ use voice recognition to rapidly tailor the view

⇒ provide pop-up hierarchical charts that allow for filtering on friendly and enemy units and weapon systems (by unit level and type)

⇒ support "John Madden [light] pen"[14] combined with collaborative connectivity so that physically separated commanders and staffs can diagram plans and interact through the "common picture" on the fly (include capability to translate final diagrams to standard map graphics)

⇒ add multiple templates to the situation map but be able to selectively filter out information by template and remember this tailoring in the context of a saved view

⇒ tailor the "cockpit" illustrated in Figure 1 by customizing on the fly what units are displayed, what graphics are used to roll up status information, and add in tailored logistics, reserve, and other information as needed

⇒ provide pop-up windows for unmanned aerial vehicle (UAV) video feeds with a visual reference on the situation map depicting UAV location and viewing direction

⇒ select a map graphic and drill down to associated detailed information by getting a pop-up window with hypertext[15] subject headings of related information available (i.e. for an

avenue of approach you might have a text analysis of the pros and cons, for a friendly unit you could have hypertext links to a mission statement, that commander's CCIR, or a pop-up unit status window)

⇒ display a visually unique border on a grid square that has UAV operating in that area or satellite imagery available

⇒ select a grid square for which imagery is desired, have a standard imagery request form pop up, fill out missing data (i.e. when needed, what resolution), and e-mail the request from the same window

Note in the last three bullets how associating related information and extracting context from information requests can have some powerful implications regarding information overload management and workflow streamlining. In the case of the request for satellite imagery, the action (request) to get the required information (imagery) is integrated directly with the context information (grid square) associated with the needed imagery. The requesting unit and grid square desired can be inserted automatically into the pop-up electronic mail request. In a similar manner, the third to last bullet above uses graphical objects (unit icons or avenue of approach arrows) to help visualize the battlefield and serve as a focal point for associated information. Rather than dig through a stack of paper or electronic messages looking for a unit's mission statement, it is easier to go to the graphic representation of that unit on the electronic situation map and pull up the related mission statement. Therefore, *graphics serve as a powerful tool in providing big picture visibility and a clear beacon for associated detail.*

To develop an effective battlefield visualization interface, designers must first gain a clear understanding of the elements necessary to build an image of the battlefield. One common analytical framework developed by the Army is mission, enemy, troops, terrain and weather, and time available (METT-T).[16] Soldiers are trained to approach all mission analysis from this perspective. Battlespace is another important framework for the operational commander.

FM 100-5 describes battlespace as a three dimensional view of the battlefield that is not constrained to the area of operations and blends the concepts of tempo, depth, and synchronization into the formulation of the commander's image.[17] METT-T and battlespace identify real world frameworks for military personnel and are excellent candidates for focusing battlefield visualization interface design. One of the traps to avoid when developing the interface is the search for a common metaphor.[18] Designers look for familiar objects like a file cabinet to build interface functionality around, hoping that the metaphor will help computer users mange related electronic processes. The disadvantage to this approach is that it sets very definite limits on the functionality of the interface. A more flexible approach to consider is an idiomatic paradigm, taking advantage of the human ability to learn idioms quickly and easily without necessarily being able to relate them to something they are already familiar with.[19] Many components of graphical user interfaces (GUI) like windows are idiomatic, but are easily learned and provide powerful capabilities.[20] The bottom line is that successful machine interfaces for battlefield visualization will depend on creative collaboration between warfighters and interface designers, prototyping and validating as they go to see what really works. Significant work is currently underway toward vastly improved interface design and capabilities. The Army is prototyping the Maneuver Control System-Phoenix (MCS-P), a battle command system that will share information between units from battalion through corps. MCS-P will include scaleable digital maps with 3-D capabilities, automatic update of enemy and friendly positions, operational overlays, voice command capability, graphical display of task organization, color coded roll-ups of subordinate unit status (personnel, fuel, and ammunition) with drill down capability for more detail,

generation of a graphical OPORD, a synchronization matrix tool, a course of action (COA) analysis tool, and video teleconferencing (VTC) to enhance collaborative planning.[21] This extensive battlefield visualization capability will go a long way toward establishing a common battlefield picture and provide a valuable tool through which the operational commander's vision can be shared.

Share the Image - The operational commander often publishes an initial version of his intent along with planning guidance early in the CES process. Successful communication of
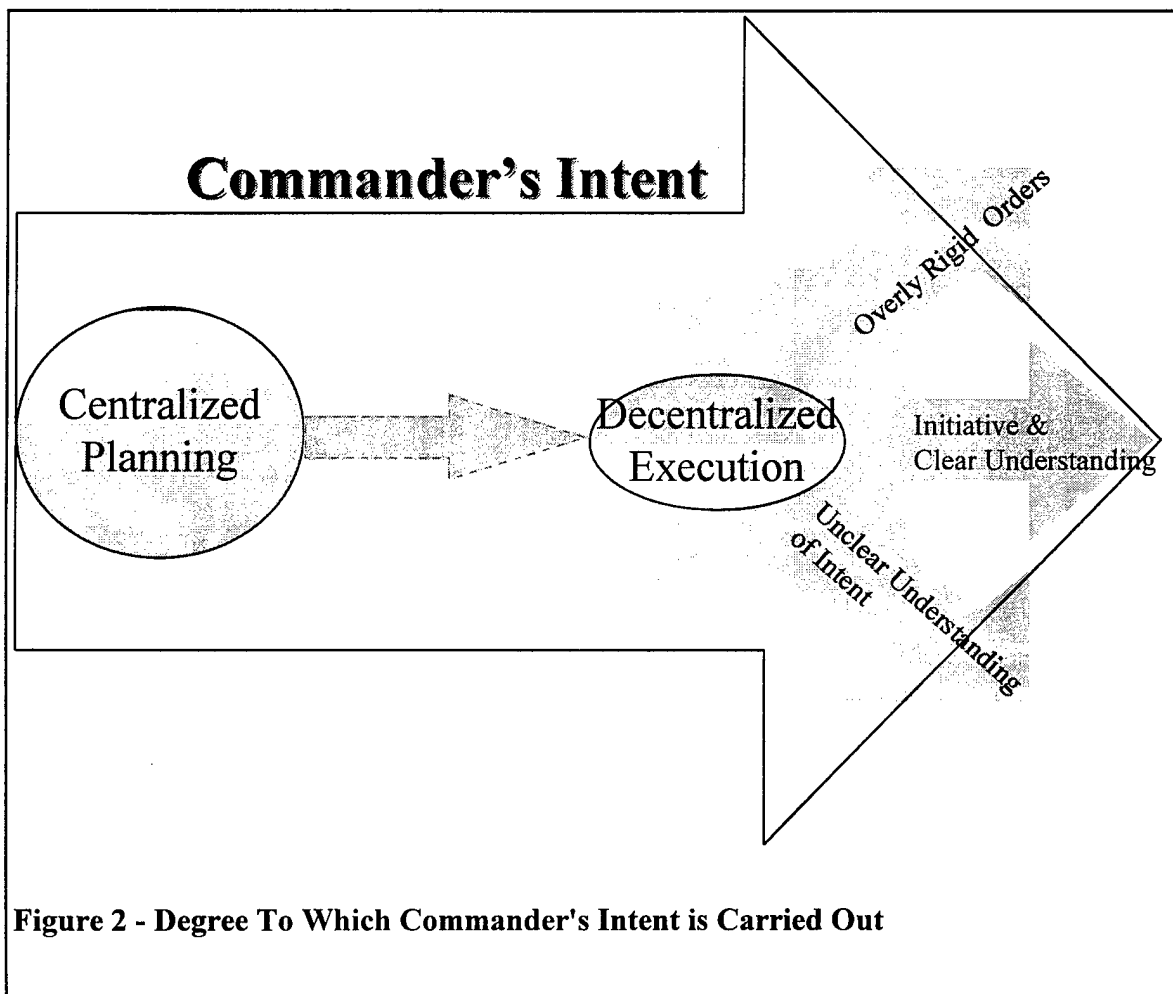
Commander's Intent

Centralized Planning

Decentralized Execution

Overly Rigid Orders

Initiative & Clear Understanding

Unclear Understanding of Intent

Figure 2 - Degree To Which Commander's Intent is Carried Out

the commander's intent -- his image of how his forces will shape the battlespace --

significantly improves planning at all echelons by aiming estimate preparation, information

gathering, and COA exploration in the desired direction. The ability of physically separated joint staff, service components, and lower echelons to orient on a common picture of the battlefield with supporting graphical representations of higher intent and purpose, greatly enhances understanding, highlights questions and maximizes the rapid achievement of the common goal in support of strategic objectives. Additionally, the ability to share this common picture with the logistics community facilitates timely support and concurrent planning for airlift, sealift, and sustainment support issues.[22] Furthermore, clear communication of image and intent ensures that the importance of changing developments impacting the intent will be recognized at several echelons and quickly communicated. The most important aspect, however, of the "common picture" capability pertains to the execution phase. It is here that the ability of forces to clearly understand the intent two levels up and see where they fit into the big picture is needed the most, because it is during execution that the operational commander must loosen the reins of control and rely heavily on the decentralized execution and initiative of subordinate commanders.[23]

This is particularly true today with the prevalence of Military Operation Other Than War (MOOTW). The Joint Task Force Commander (JTFC) faces a potentially more complex environment in MOOTW where actions taken at both the tactical and operational level can have strategic repercussions. The common mixture of joint, combined, and non-governmental elements in MOOTW dramatically increases the importance of a common battlespace picture and the ability to employ interactive, real-time collaborative graphics and VTC in order to share the commander's image, ensure understanding of his intent, and expedite the communication of critical information back to the commander.

Computer animation is a valuable tool that aids in image sharing. It goes far beyond written text or even graphical diagrams to convey exceptional understanding of movement, timing and synchronization. Here, use of a metaphor in support of interface design will likely prove valuable. An interface similar to a simple video editing and playback station with controls much like home VCRs will facilitate building and viewing animated concept of operations (CONOPS). Special animation objects like a flashing lightening bolt connecting force elements can illustrate hand-off, coordination and synchronization. Additional capabilities are needed to jump to various parts of the animated operation like the beginning of phases, or specific times (i.e., D+3, H+5). A graphical representation of the synchronization matrix would be useful as an entry point to corresponding frames in the animation sequence, and to control the highlighting of a particular force element as the animation is played. Control points should also be available to allow divergence into branches that have been developed. One current related effort is the Mission Planning and Rehearsal Training System (MPRTS). It will have the ability to display a 3-D interactive OPORD and use a virtual reality based "virtual sandtable."[24] Together with related systems, this will provide powerful tools for operational planning and mission rehearsal. One consideration, however, is the requirement for these tools to deliver *scaleable utility*. Operational planning may take place under significant time constraints. Examples include MOOTW involving hostages or rapidly changing circumstances during conventional mission execution. Under these circumstances, plans may need to be built rapidly and roughly without the luxury of broad and complete supporting details. Future planning tools and their interfaces must support this environment as well.

Monitor Understanding, the Changing Situation, & Execution Utilizing the animation support tools described above at operational and tactical levels provides several benefits. Subordinate elements could build their own animated CONOPS that would significantly aid brief back. It would also allow the operational commander to drill down within the operational animated CONOPS to ensure his intent was being followed and even zero in on planning and synchronization at decisive points. It is recognized that this capability could lead to micromanagement. Training, discipline, and emphasis in doctrine supporting the operational commander's responsibility to dictate the *what* without dictating the *how* will play important roles in alleviating this potential problem.

Another important monitoring tool is the alarm.[25] Circumstances change constantly throughout the battlespace. A lot of the incoming change information arrives in electronic format, and here interface designers can play an important role in the display and notification of change information in a manner that informs but does not overwhelm. The operational commander must predetermine what changes are significant and be able to easily dictate the level of intrusion provided by automatic change notification. For example, arrival of e-mail traffic from higher or subordinate commanders may be represented by a flashing message icon. Movement of a particular enemy unit past a specific grid point before a specified time, or the change in force ratios beyond a provided limit could involve the dual alert notification of a flashing unit map icon coupled with the delivery of a flashing alert e-mail message. At a higher level of intrusion, an audible alarm could sound upon battlefield sensor detection of employed NBC agents. To provide maximum flexibility, alerts to changing information must allow a wide spectrum of information to be tagged and a range of intrusion levels to be set.

Additional techniques must be provided to highlight what information changed in order to minimize the time required to discover and assimilate the change. OPORD changes, for example, should be easy to jump to and understand. Adapting standard techniques for highlighting changes to paper military publications, electronic OPORDs could display deleted portions lined out in red, and all additions bolded and underlined. Similar techniques could be used for graphical or animated information that would allow the viewer to jump to changes and see a split screen of the old and new graphics or animation sequence. This allows rapid digestion of changed content without having to go through the entire OPORD.

The growing capability to monitor real-time battlespace change may even provide some support to the difficult task of recognizing and taking measures to postpone the culminating point of battle through proactive logistics synchronization.[26] Logistics sensors rolling up ammunition, fuel, and equipment status information can help speed the right support, to the right place at the right time.

Workflow & Retrieval

> *"The history of command can thus be understood in terms of a race between the demand for information and the ability of command systems to meet it."*
>
> Martin Van Creveld (from <u>Command in War</u>)[27]

Management of the figurative firehose of information being blasted across the battlefield in the form of imagery, voice and message traffic, graphics, and video is in need of radical paradigm shifts across several processes to include the actions that trigger information generation, the control of information receipt, and the means of information retrieval. Two examples illustrate aspects of the problem. One study revealed that during Desert Storm an

estimated 80% of intelligence traffic was redundant.[28] Another author described the

generally slow and complex process for getting intelligence information from corps down to

the tactical commanders.[29] The heart of the matter revolves around the following

information triad; information *identity*, information *tracking*, and information *receipt control*.

Information loses its *identity* when it becomes buried inside a paper or electronic stack of

messages queued in no specific order for review and assimilation. Information retrieval and

management become a time consuming sequential process that grows more difficult in

proportion to the amount of information. To solve this problem a) *identity must be added to

information* in the form of a grouping or classification[30] scheme as it is disseminated, and b)

the majority if not all *information developed must be directed to a predetermined location.*

Categorizing information into major groups (e.g. requests, decisions, information), sub-

groups (e.g. logistics, maneuver, fire support, intelligence, objectives) and so on aids

workflow management and retrieval by providing a semi-direct means of retrieval versus the

previous search for the "needle in a haystack." To put this utility in perspective, over 19,000

messages were received through intelligence channels by one division during Desert Storm

operations.[31] Directing generated information into predefined storage structures or templates

provides a framework in which the best of both "push" and "pull" strategies can be realized.

Information is "pushed" to data bases replicated across battlefield echelons and is available

no matter who requested it. This allows for timely delivery of a wealth of information

without overloading commanders. Data on demand, in line with the situational nature of

information, can be satisfied by allowing users to "pull" information as needed from these

information repositories.

The next problem to address is a better process for *tracking* information or action requests. Much of the initiation and subsequent follow-up of this "work"[32] is normally done by voice or e-mail. This generates not just too much message traffic, but *unconnected* message traffic.[33] Supported by the information identity concept above, a new workflow oriented process to replace e-mail is needed that provides organization by being database-centric. Under this scheme, commanders will have an interface that looks very much like today's windows-based e-mail software with windows for electronic in and out boxes, and utilities to

Figure 3 - Utilizing Workflow Capabilities
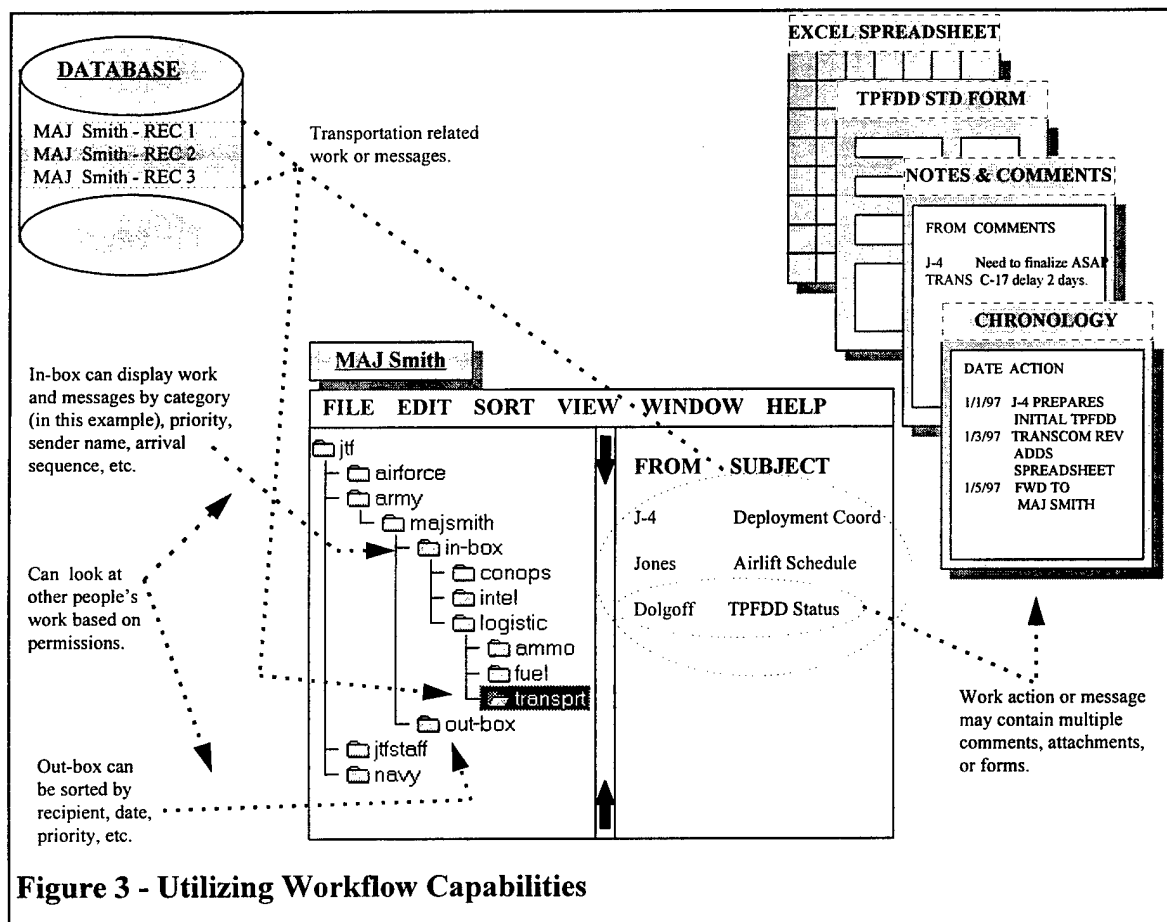
tailor what is viewed through category selection and other techniques. However, work that is generated by message or electronic form will actually be stored as a record in a database.[34] The recipient, using the same workflow software, will open his electronic work in-box and

any work in the database for him will appear. This has several powerful implications for organizing and tracking work. Because all transformation of work to include the addition of comments, attachments (graphics, spreadsheets, text files), and a chronological list of who it has passed through is all stored as a single database record, it is simple to retrieve all associated history and information. In addition, the ability of subordinates to electronically determine who currently has the work relieves pressure on the operational commander and staff by significantly reducing voice and message traffic trying to track down status. Work can be broadcast to several people at once so that collaborative or independent work can take place. Numerous ways to view incoming and outgoing responses or requests are possible in conjunction with information identity implementation. Work can be viewed by date-time-group, by person, by topic with easy navigation down several category levels, and by user defined priority. In addition, commanders could call up subordinate commander's work requests to ensure they were being satisfied.[35] Lastly, when the work is complete, it appears with all associated history in the electronic in-box of the originator. Commanders would have a process that facilitates focusing on critical concerns while at the same time making it harder for information to get overlooked, buried or lost.

Receipt control, the final leg of the triad mentioned above, can be implemented by building upon the other two legs. Outgoing requests for information can be prioritized so that they pop to the top when they appear as incoming responses. Control of incoming response traffic would be possible for the first time because requests and responses are now linked. In addition, isolation of responses ensures immediate recognition and allows for alarm notification setting at various levels. Responses to CCIR, for example, could be

isolated from all other incoming traffic and trigger the most intrusive alarm. Another necessary capability related to receipt control is the ability to set and prioritize requests directly to information repositories. This involves the concept of *intelligent* or *active databases*; a shift from passive to active repositories that do not just accept data or allow it to be pulled via query, but can actively analyze data changes and, in conjunction with user-defined rules, automatically send out change notices or update situation templates and maps.[36] This could become a powerful tool for managing information overload by allowing commanders to establish ad hoc control over the alert notification method for specific changing information. It would also eliminate manual requests for certain kinds of information by allowing commanders to directly queue up at the information source.

Organizations

Implementation of the information triad as described above together with universal connectivity and common visualization of the entire battlespace presents numerous issues with regard to organization for command and control. In this new environment, the current hierarchical structure may impede rather than facilitate rapid decision making, high optempo, and information flow. Future operational commands will probably retain a hierarchical composition, but are likely to be characterized by increased span of control and flatter overall structures.[37] By eliminating the need to pass information through an extended hierarchy we save time, reduce message distortion, and facilitate the question and answer process.[38] Concerns have been expressed regarding higher commanders providing overly specific guidance and direction given their expanded capability to view the battlespace at all levels.

The role of the intermediate commanders is increasingly brought into question. However, these concerns fail to view operational art through the lens of future organizational structures that will be epitomized by smaller, more mobile forces with greater operational reach that can be synchronized to concentrate effects of great precision and lethality from geographically scattered areas. It is also not unreasonable to expect national level assets being created to support the operational commander's management of information. In one possible scenario, an auxiliary "shadow command cell" based in CONUS working in shifts around the clock could conceivably provide direct support to the operational commander reporting through his Chief of Staff. The mission of this shadow command would primarily be information gathering and organizing, and potentially supporting analysis of developing COA's. Tied into the operational commander's battlefield image, this warfighter-staffed information support organization would work with the advantage of direct access to national assets and the entire battlespace through a global information infrastructure. They would be focused on the operational commander's critical information requirements and facilitate rapid information delivery, as well as scanning the battlespace at all levels for changing information relevant to the operational commander's concerns. Efforts are ongoing to brainstorm and test the integration of new organizational concepts with evolving doctrine and technology. The Army's Prairie Warrior '95, a simulated joint and corps-level exercise, included Knowledge Processing Teams.[39] Additional experimentation with a division level Digitized Battle Staff is examining the issues of organizing around information and optimizing information flow.[40]

Caveats and Recommendations

There will always be uncertainty in war. Leadership, judgment, experience, and insight are critical factors that are uniquely human and will not be replaced by automation any time soon. Software tools can provide valuable assistance in formulating plans and making decisions, but they must be used judiciously. Human input will always be needed to prevent decision paralysis from occurring as a result of a never ending search for either all the information or the perfect solution. Furthermore, we must be careful not to develop over reliance on these powerful new automated capabilities. In his book on information usage during the Persian Gulf War, Alan Campen warned that "Armies that seek victory by fighting smarter--and this is now the foundation of U.S. military doctrine--will quickly falter and die if the flow of battle information is interrupted or distorted."[41]

Indeed, an entirely new mindset is emerging with regard to weapons development. C2 systems have now taken center stage as the drive to integrate and orchestrate combat power components in order to *synchronize effects* has led to a greater focus on the whole.[42] In conjunction with this new ordering of priorities, it is vital that a similar reorientation occur to capitalize on the emerging global infosphere.[43] Information collection, analysis, dissemination, and viewing must be built upon a common framework of information organization principles to support "pushing" prepositioned information availability and "pulling" situationally tailored information as needed. With this in mind, the following principles are suggested to help tame the emerging information firehose:

⇒ *build systems from common definitions of information* -- an information model that defines a global, physically distributed, logically centralized information repository organized to facilitate tailorable information retrieval

⇒ *provide warfighters the same interface for battlefield visualization* -- variations in utilities and level of detail based on level of war, commonality across echelons and services facilitates communication, joint efforts, and training as commanders and staff progress from tactical to operational levels

⇒ *databases must be active, not passive* -- we should not have to go find information, it should come to us in accordance with user-defined notification mechanisms

⇒ *use graphics as the focal point for locating related information* -- automatic feeds from database updates to electronic situation maps, drill down from map graphics to supporting detail information

⇒ *manage by exception through receipt control* -- tailorable alarms and prioritized notification of messages, work completion, and information change

⇒ *information must possess identity and, when possible, be stored (as it becomes available) in predetermined formats and locations* -- this allows semi-direct retrieval and information requests directly to the source, and facilitates tracking

⇒ *information manipulation must be scaleable* -- tools can function and produce usable products in an "outline" planning and analysis mode if time is scarce and/or information is limited

⇒ *maintain separation between operational and tactical decision making* -- shields operational commander from information overload by eliminating the need for the same degree of low level tactical knowledge.[44]

⇒ *the user interface is a critical component of any system* -- good interfaces facilitate information location, organization, and assimilation and aid understanding

⇒ *information discipline must be reemphasized in training* -- dealing with the availability of so much information will require new emphasis in decision making training

⇒ *be prepared to use "stubby pencil"* -- in case of system failure, all critical information/situation awareness in the form of maps and reports must be available as hardcopy

Adhering to these principles will deliver *improved sharing of the commander's image* and

increased understanding in *less time*. This will significantly shrink the operational

commander's decision cycle and allow him to orchestrate his intent through synchronized

actions characterized by rapid tempo, concentrated effects, and parallel operations that will disrupt the enemy's decision cycle and overwhelm his ability to react or even to plan. Numerous initiatives like the Joint Warfighting Interoperability Demonstrations (JWID) are underway, integrating advanced technology efforts across the services to provide the warfighter with near real-time and real-time access to the entire spectrum of battlespace information. Proper focus on human factors engineering will contribute significantly to taming this looming information firehose.

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[1] U.S. Department of the Army, FM 100-6 Information Operations (Washington D.C., Government Printing Office, August 1996), 6-0.

[2] James P. Kahan and others, Understanding Commanders' Information Needs (The RAND Corporation, June 1989), 1.

[3] Department of Defense, Final Report to Congress: Conduct of the Persian Gulf War (Washington D.C., Government Printing Office, 1992), 560.

[4] James P. Kahan and others, 1.

[5] Joint Military Operations Department, Operational Functions (Naval War College, NWC 4103, August 1996), 1-2.

[6] Kathryn Alesandrini, SURVIVE Information Overload - The 7 Best Ways to Manage Your Workload by Seeing the Big Picture (Business One Irwin, Homewood, Illinois, 1992), 1.

[7] Andrew C. Braunberg, Brain's Affinity for Imagery Eases Information Overload (SIGNAL, AFCEA's International Journal, December 1996, 49

[8] Chunking is a similar concept that allows for a form of abstraction by breaking related information into recognizable chunks or patterns for better retention.

[9] U.S. Department of the Army, Training and Doctrine Command, TRADOC Pamphlet 525-70 "Battlefield Visualization Concept" (Fort Monroe, Virginia, 1 October 1995), 2.

[10] Alan Cooper, About Face -- The Essentials of User Interface Design (IDG Books, 1995), 135.

[11] James P. Kahan and others, 2-6. While it is hard to imagine when Enemy Situation and Friendly Situation information will not be needed, level of detail will most likely still be situation dependent. Note that FM 101-5 pg 6-5 defines critical information as follows: "Critical information directly affects the successful execution of operational or tactical operations."

[12] Joint Military Operations Department, Commander's Estimate of the Situation (CES) - Worksheet for In-

Class Work (Naval War College, NWC 4111, July 1996). This document serves as a template for the CES in worksheet format, describes what information should be included in the CES, and provides some examples. Further discussion of the CES process in this paper is based on the CES worksheet guide.

[13] Naturally as the situation changes, it is very possible that new information may become critical and added to the CCIR (just as other information may no longer be needed and is therefore removed). (Kahan and others, pg 36) make the point that information is used to constantly test the commander's image of the battlefield, and the results of that test guide what further information may be required.

[14] Philip R. Tilly, A Recommendation For The Heavy Division Command Group (U.S. Army Command and General Staff College, Fort Leavenworth, Kansas, 1994), 139. From survey comments, the "John Madden pen" refers to the ability of a well known TV football commentator to draw digital diagrams that can be seen on the viewer's TV screen at home.

[15] William M. Newman and Michael G. Lamming, Interactive System Design (Addison-Wesley Publishing Company, 1995), 303. They define hypertext as "... documents written non-sequentially and intended for non-sequential reading (Carmody et al., 1969)."

[16] U.S. Department of the Army, FM 100-5 Operations (Washington D.C., Government Printing Office, 1993), 2-4.

[17] Ibid, 6-13.

[18] Alan Cooper, 53.

[19] Ibid, 56.

[20] Ibid.

[21] Battle Command Battle Laboratory, "Maneuver Control System-Phoenix Enhancements For Battlefield Visualization." linked. U.S. Army Battle Command Battle Lab at "Experimentation Projects." < http://cacfs.army.mil/mcsbv.html> (6 February 1997), and AE3 Program Office, Army Experiment III CD-ROM (Fort Leavenworth, Kansas, September 1996), "Experiments - MCS-P Applique".

[22] AE3 Program Office, Army Experiment III CD-ROM (Fort Leavenworth, Kansas, September 1996), "Experiments - Log Anchor Desk". Currently, the Logistics Anchor Desk (LAD) is one initiative underway that will allow logistics planning technology to tie into the operational commander's common picture of the battlefield and operational planning information.

[23] Richard E. Simpkin, Human Factors in Mechanized Warfare (Brassey's Publishers Limited, 1983), 152.

[24] Battle Command Battle Laboratory, "Mission Planning And Rehearsal Training System (MPRTS)." linked. U.S. Army Battle Command Battle Lab at "Experimentation Projects." < http://cacfs.army.mil/mprts.html> (6 February 1997).

[25] Kahan and others, 42.

[26] Joint Military Operations Department, Elements of Operational Warfare (United States Naval War College, NWC 4096, August 1996), 23. This document defines the culminating point as "... the point of a culmination occurs in time and space when and where the attacker must stop and defend his gains if he wishes to avoid losing them." on page 21.

[27] Joint Pub 6-0, <u>Doctrine for Command, Control, Communications, and Computer (C4) Systems Support of Joint Operations</u> (U.S. Government Printing Office, Washington D.C., 30 May 1995), IV-1.

[28] Alan D. Campen, <u>The First Information War</u> (AFCEA International Press, Fairfax, Virginia, 1992), 59.

[29] Joseph A Moore, <u>Gaining Order From Chaos: Will Automation Do It?</u> (School of Advanced Military Studies, US Army Command and General Staff College, Fort Leavenworth, Kansas, First Term AY 92-93), 32-33.

[30] Kathryn Alesandrini, 9.

[31] Philip R. Tilly, <u>A Recommendation For The Heavy Division Command Group</u> (U.S. Army Command and General Staff College, Fort Leavenworth, Kansas, 1994), 143. The information is attributed to LTC Keith Alexander, former G2 of 1st Armored Division.

[32] In this context, work can refer to a plain e-mail message, an electronic form for a particular action (i.e. an intelligence template to fill out, or a set of related electronic forms .

[33] The Joint Maritime Command Information System (JMCIS) Automated Message Handling System is attacking this issue by providing Message Profiling (the ability to sort incoming messages into queues) and Catalog Query (the ability to search through old message traffic for specific information).

[34] In reality, we will need to replicate this database across the battlespace to provide a common picture and access by all.

[35] Once again we get into an area where micromanagement could present problems. Is the cure better than the disease?

[36] Lawrence E. Casper and others, <u>Knowledge-Based Warfare: A Security Strategy for the Next Century</u> (Joint Forces Quarterly, Autumn 1996), 87.

[37] Gordon R. Sullivan and James M. Dubik, <u>War in the Information Age</u> (Strategic Studies Institute, U.S. Army War College, Carlisle Barracks, PA, 1994), 8.

[38] Jeffrey R. Cooper, (DRAFT) <u>The Coherent Battlefield -- Removing the "Fog of War": A Framework for Understanding an MTR of the "Information Age</u> (SRS Technologies, June, 1993), 15.

[39] AE3 Program Office, <u>Army Experiment III CD-ROM</u> (Fort Leavenworth, Kansas, September 1996), "Experiments - Force XXI - Force XXI Brochure", 8.

[40] John E. Miller, "Force XXI Battle Command" (linked. <u>FORCE XXI Home Page</u> at "Joint Venture Home Page." <http://204.7.227.75:443/force21/jv/jv-essay/bcessay.html>, (6 February 1997)), 4.

[41] Alan D. Campen, 89.

[42] Jeffrey R. Cooper, 6.

[43] Command, Control, Communications, and Computer Systems Directorate (J-6), <u>C4I for the Warrior</u> (the Joint Staff, the Pentagon, Washington D.C., 12 June 1993), 10.

[44] Jeffrey R. Cooper, 19.

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